POSSIBILITY OF USING WASTE TIRE COMPOSITES REINFORCED WITH OIL PALM FROND AS CONSTRUCTION MATERIALS

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ABSTRACT

Today, Malaysia is one of the largest countries planting palm tree worldwide. During the lifespan of this tree, there is abundance of fronds being trimmed and left there to biodegrade them by the nature which can affect the environment and the tree. Along with that, there is another waste produced result from the growth in technologies and transportation industries which is waste rubber tires. It seems that both wastes have limited application in industry nowadays. Therefore, this research proposed is to make use of both wastes to produce something worth which is a composite use for producing particle boards for construction purposes. The production methods used are fiber surface treatment with alkali solution and composite preparation using Hot and Cold Molding Press. The characteristics and properties of the particle board from palm fronds-rubber tires and palm fronds alone are studied and compared using Universal Testing Machine (UTM). It can be said that the particle board produced have comparable characteristics and properties especially its flexibility and flexural properties.

ABSTRAK

Dewasa kini, Malaysia merupakan salah satu negara terbesar yang menanam pokok sawit di dunia. Sepanjang jangka hayat pokok ini, terdapat banyak daun pelepah yang dipotong dan dibiarkan di kawasan sekitarnya untuk mengalami biodegradasi. Secara semula jadi, tetapi proses ini akan memberi kesan sampingan terhadap pokok sawit dan juga kawasan persekitarannya. Selain daripada itu, terdapat satu jenis hasil buangan lain yang terhasil kesan dari teknologi dalam industri pengangkutan iaitu tayar getah terpakai. Kedua-dua jenis hasil buangan ini mempunyai applikasi yang terhad dalam industri pada hari ini. Oleh itu, penyelidikan bertujuan untuk menghasilkan papan partikal daripada gentian pelepah sawit dan tayar terpakai untuk kegunaan pembinaan. Kaedah penghasilan papan partikal yang digunaakan terdiri daripada rawatan permukaan gentian dengan larutan alkali dan penyediaan komposit dengan menggunakan Mesin acuan bertekanan panas dan sejuk. Ciri-ciri dan sifat mekanikal papan partikal yang terhasil daripada gentian pelepah sawith dan tayar terpakai dianalisis menggunakan Mesin Ujian Universal (UTM). Secara keseluruhannya, ia boleh dikatakan bahawa papan partikal yang dihasilkan mempunyai ciri-ciri yang setanding dengan papan partikal dipasaran terutamanya sifat fleksibiliti dan lenturannya.

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LIST OF SYMBOLS

ρ	-	Density
ε	-	Strain
σ	-	Stress
%	-	Percentage

LIST OF ABBREVIATION

cm	-	centimeter
g	-	gram
IB	-	Internal Bonding
kg	-	kilogram
kg/m^3	-	kilogram per meter cube
mm	-	milimeter
MOE	-	Modulus of Elasticity
MOR	-	Modulus of Rupture
Mpa	-	Mega Pascal
NaOH	-	Sodium Hydroxide
N/mm^2	-	Newtown per millimeter square
OPF	-	Oil Palm Fronds
P	-	Pressure
T	-	Temperature
TS	-	Thickness Swelling
t	-	Time
UTM	-	Universal Testing Machine
vs	-	Versus
^0C	-	Degree Celcius

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Nowadays, the natural sources are more preferable than the synthetic materials. This also due to the wood-based industries and product that highly demand in the market based on diverse application for interior and exterior uses such as furniture, cabinets, millworks, construction materials, pool tables, floor underlayment and etc. But, there is shortage of the wood as the raw material, people start looking at other sources of lignocellulose materials that can replace the function of wood in this industry. In composite production such as plywood and particleboard, they start replacing the wood materials with agro-forest waste and agricultural residues which call as natural fibre.

Natural fibres that have been used in wood-based industries (plywood, particleboard, composites) is tea leaves waste, almond shells, flax shiv, wheat straw and corn pith, branch wood, decayed wood, durian peel and coconut coir, bamboo, kiwi pruning, tobacco, bagasse, oil palm empty fruit bunches, trunk and stem (Abdul Khalil,

Nurul Fazita, Bhat, Jawaid & Nik Fuad, 2010; Nemli, Demirel, Gumuskaya, Aslan & Acar, 2009; Yang, Kim, Lee, Kim, Jeon & Kang, 2004). In addition, natural fibres usually have several advantages which are though they have poor strength properties due to low density; it can lead to high specific strength properties. They are abundantly available resources that having low cost, low energy consumption and non-toxic to work with (Satyanarayana, Sukumaran, Mukherjee, Pavithran & Pillai, 1990).

Natural fibre is one of the lignocellulose materials that have some characteristic like wood materials. Cellulose is a hydrophilic glycan polymer consisting of a linear chain of 1, 4-β anhydroglucose unit which contains alcoholic hydroxyl groups. Usually the absorption of the cellulosic material are depends on the purity of the cellulose (treated or untreated) and the degree of crystallinity of its structure (Mohd Aizuddin, 2010). All of the characteristic and properties of this cellulose are really important because it will affect the corporation when mixed with matrix.

For oil palm tree, it is produced in 42 countries worlwide on about 27 million acres. In Malaysia itself, the total planted area of palm tree increased to about 3.87 million hectares in 2004 (Abdul Khalil et al., 2010). Every year, production of oil palm will contribute around to 15.8 and 8.2 million tons of oil palm empty fruit bunches (EFB) and trunk (OPT). It is believe that the numbers of oil palm fronds (OPF) are much bigger than its empty fruit bunches and trunk that produce each year.

Other than that, the fast developments of the economy especially with broaden of technologies apply everyway. As this scenario interminable, the demand of the automobiles will keep increasing. The problem that occurs because of this demand is the abundance of the waste rubber tires while the sources of the rubber itself will decrease. Based on the statistic data that have been analyzed, approximately 1.5 billion tires are discarded every year worldwide (Jun, Xiang-min, Jian-min & Kai, 2008) that happen because the lifetime of each tires are quite short. Therefore, one of the biggest

problems is how avoid environmental pollution that may cause by the waste rubber tires. Thereby, it is necessary to develop some methods for reused and recycling all the waste tires. Since most of the composition of the tires is rubber, it has properties such as high strength, resist abrasion, durable, elastic and anti-caustic that have high potential to be recycle as new raw materials.

1.2 PROBLEM STATEMENT

Malaysia has a large population of palm tree plant which has a life span of about 25 years. Yearly, there is abundance of oil palm fronds (OPF) that will be assemble around the palm tree after been trimmed. The OPF needs more than a month to be naturally degradable and along this process, it will promote the production of bacteria and fungus that may harm the soil and also the palm tree. Other than that, it also produce unpleasant odor to the surrounding.

Other than that, the number of waste rubber tire keeps increasing day to day. The application of it was subjected to producing rubber nuggets/buffing, as filler and it will be process back to produce metal and hydrocarbon (black carbon) or also been reused as a whole for application such garden decoration, tree guard, shock absorbent and fences. To abroad the application, this research proposes to make use the waste rubber tires as the reinforced composite to produce particle board when mixing with the OPF fibre.

1.3 OBJECTIVE

Objectives of this research are:

(i) To make use the waste of oil palm fronds (OPF) and rubber tires.
(ii) To produce particle boards of oil palm fronds (OPF) fibre and waste rubber tires.
(iii) To study the effect of alkali treatment to the physical and mechanical properties of the oil palm fronds (OPF) fibre particle board.
(iv) To study the effect of waste rubber tires composition to the physical and mechanical properties of the oil palm fronds (OPF) fibre-waste rubber tires particle board produced.
(v) To compare the characteristics and mechanical properties between oil palm fronds (OPF)-waste rubber tires particle board with palm fronds particle board.

1.4 SCOPE

In order to achieve the objectives of this research, the scope of the research will cover on the production of the particle board from both wastes which is trimmed oil palm fronds (OPF) and rubber tires. Different variables will be use during the experimental process such as the composition between trimmed oil palm fronds (OPF) and rubber tires, the alkali treatment of the trimmed oil palm fronds (OPF) and the pressure applied during cold and hot press. The data collected will be comparing between the particle board produce from trimmed oil palm fronds (OPF) fibre particle board and industrial grade particle board.

1.5 RATIONALE AND SIGNIFICANCE

Based on the objectives and scope that have been carried out, several rationales and significant of this research can be outline which is:

(i) The trimmed oil palm fronds, OPF (oil palm biomass) can be fully utilized.
(ii) The amount of waste rubber tires will decrease as it can be recycled to be raw materials in wood-based processes.
(iii) The environmental pollution will be lesser.
(iv) The physical and mechanical properties of the particle board produce will be comparable with the industrial particle board available (wood-based materials).

CHAPTER 2

LITERITURE REVIEW

2.1 INTRODUCTION

In this chapter, all information's regarding this research and study are briefly discussed, explained and supported with several reviews which extracted from several sources of journals, reference books and articles. There are five major topics that discussed in this chapter which is composites, natural fibre, oil palm fibres (OPF), rubber tires and conclusion.

2.2 COMPOSITES

Basically, all know that composites are the mixture or combination of fibre and adhesive as binder which pressed and bind together to yield strength and rigidity. In other words, composites are materials that comprise strong load carrying material (known as reinforcement) imbedded in weaker material (known as matrix) (Taj, Munawar & Khan, 2007). It was really important to study the characteristics and

properties of each of the fibre, matrix and adhesive used before mixed them together. The constituents of the composites will retain their individual, physical and chemical properties that produce combination qualities which they would be incapable of producing alone (Taj et al., 2007). With the development of wood-based industries and shortage of wood as raw materials, people start searching new sources that has lignocellulosic properties that can replace the wood as raw materials. Most of the sources are materials from agricultural residues and non-wood plant fibres.

2.3 NATURAL FIBRES

Natural fibres can be considered as naturally occurring composites consisting mainly of cellulose fibrils (fibres) embedded in lignin matrix (resin). These cellulose fibrils are aligned along the length of the fibre, irrespective of its origin, whether it is extracted from bark or stem, leaf or fruit (Satyanarayana, Sukumaran, Mukherjee, Pavithran & Pillai, 1990). There are many research has been carried out on wide variety of those materials from many different regions of the world: wheat straws, rice husks/straws, tobacco, bagasse, sunflower stalks, kenaf, bamboo, oil palm, maize husk and cob, kiwi pruning, paulownia, cotton carpel, durian peel and coconut coir, vineyard pruning, decayed wood, oil palm emptry fruit bunches, trunk and stem (Nemli et al., 2009; Tabarsa, Jahanshahi & Ashori, 2011).

The uses of natural fibres in wood-based industries have developed biodegradable composites which can be safely use without affecting the environmental conditions (Hamzah, 2009). Indirectly, the uses also can reduce current problem regarding environmental pollution and ecology problem. Other than that, it also economical compare to inorganic fibres that produce from synthetic materials. Realizing on the potential of many types of natural fibres that can be utilized, many reseach studies have been conducted to studies the properties and characteristic of natural fibre

especially from agro-waste and biomass because it was low cost and low energy consumption.

There is a growing interest on natural fiber composites in various fields due to these advantages. Automotive giants such as Daimler chrysler use flax–sisal fiber mat embedded in an epoxy matrix for the door panels of Mercedes benz E-class model (John & Thomas, 2008). Coconut fibers bonded with natural rubber latex are being used in seats of the Mercedes benz A-class model. The Cambridge Industry (an automotive industry in MI, USA) is making flax fiber-reinforced polypropylene for Freightliner century COE C- 2 heavy trucks and also rear shelf trim panels of the 2000 model Chevrolet impala. Besides automotive industry, lignocellulosic fiber composites have also found their application in building and construction industries such as for panels, ceilings, and partition board (Hariharan & Khalil, 2005). Nowadays fiber-reinforced plastic composites find applications in fields such as aerospace, automotive parts, sports and recreation equipment, boats, office products, machinery, etc. (Sreekala, George, Kumaran & Thomas, 2002).

2.4 OIL PALM BIOMASS

Oil palm, Elaeis guineensis, is a tree whose fruits are used for extraction of edible oil (Kelly, Lee, Mohamed & Bhatia, 2007). Originated from South Africa, it is cultivated in all tropical areas of the world and it has become one of the main industrial crops. The reddish colored fruit grows in large bunches, each weighing at about 10–40 kg. Inside each fruit is a single seed, also known as the palm kernel, surrounded by the soft pulp. The oil extracted from the pulp is edible oil used as cooking, while that extracted from the kernel is used mainly in soap-manufacturing industries. (Kelly, Lee, Mohamed & Bhatia, 2007).

Oil palm is a multipurpose plantation and also a prolific producer of biomass as raw materials for value-added industries (Basiron & Simeh, 2005). For example, fresh fruit bunch contains only 21% palm oil, while the rest 6–7% palm kernel, 14–15% fiber, 6–7% shell and 23% empty fruit bunch (EFB) are left as biomass (Umikalsom, Ariff, Zulkifli, Tong, Hassan & Karim, 1997).

Nowadays, oil palm is now one of the major economic crops in a large number of countries, which triggered the expansion of plantation area around the world (Yusoff, 2006). This happen because the oil palm tree can grows well in wet, humid parts of tropical Asia. The data of estimation on the oil crops production in Asia for 2007 is 26,120,754 MT (DOA, 2009) while the total area of planted oil palms in Malaysia stood at 4.3 million hectares in 2007 taking Malaysia the largest producer of palm oil in the world.

Table 2.1: Land area of crops planting and annual production in Malaysia for year 2007

	Area of planting, Ha	**Production, MT**
Oil palm	4 304 914	26 1204 7
Rubber	1 229 940	1 119 553
Paddy	676 111	2 375 604
Fruits	287 327	1 871 262
Vegetables	42 832	694 811
Field crops	12 979	129 302
Herbs	495	890
Pepper	4 896	43 932
Flowers	1 895	154 974 350
Coconut	117 650	504 824
Coffee	7 100	30 550
Sugarcane	14 670	733 500
Tea	2 784	5 540

(Source: FAO, 2007)

Expectedly, large and abundant quantity of oil palm fronds (OPF) are naturally generated by this process, which presently are underutilized and are often buried in rows within the palm plantations.(Salman & Hameed, 2010). Effect from the development, Malaysia is ranked as the world's leading palm oil producer and exporter, accounting for 47% of global palm oil production and 89% of exports (Sumathi, Chai & Mohamed, 2008). In Malaysia, the production of palm oil is targeted to increase from 8.5 million tons in 2000 to 10.5 million tons by 2010. (Hanim, Azemi & Rosma,2011).

2.5 OIL PALM FRONDS, OPF

In Malaysia, oil palm industries are one of the bigger industries that have been developing such year. Each year, there will be abundance of biomass produced from the production of these industries. This make the potential to utilized all the biomass become wider especially when the sources of cellulose materials been use to replace the function of wood in wood-based industries. Loh, Paridah, Hoong, Bakar, Anis and Hamdan (2011) stated that stem of oil palm trees are one of the most potential residues available in Malaysia. Being a monocot, the oil palm stem differ with wood in term of cell types and arrangement. It is very hygroscopic in which it shrink and swells easily upon the loss and gain of water respectively. Cellulose, hemicellulose, and lignin made up the cell wall and are responsible for most physical and chemical properties exhibited by lignocellulose materials.

Based on all journals available, the replacement of wood raw materials with oil palm biomass in producing composite and plywood have improved some properties such as bending strength, screw withdrawal and shear strength. It also eventually increased the added value of these residues (oil palm biomass) for use as interiors and exteriors. Furthermore, the treated oil palm biomass will also enhance the mechanical and physical properties of the composites produced. This has been discovered by Loh et

al. (2011) that oil palm stem that soaked in low molecular weight phenol formaldehyde for 20 seconds before drying will yield better properties compared to untreated oil palm stem.

Oil palm frond (OPF) is a suitable raw material because it is an abundant waste material produced by the palm oil industry in Malaysia (Goh, Lee & Bhatia, 2010). As the world's second largest palm oil producer, Malaysia generated approximately 38,256 dry kton of oil palm lignocellulosic biomass in the year 2007, of which OPF comprised 44% (Goh et al., 2010).

Oil palm biomass including oil palm fronds are generally consists of cellulose, hemicellulose and lignin, and composition varies according to plant species. Cellulose with a molecular weight of about 100,000 is essentially a polymer with linear chains of glucopyranose units linked to each other by its 1, 4 in the a configuration (Kelly-Yong et. al, 2007). Hemicellulose is a complex mixture of several polysaccharides such as mannose, glucose, xylose, arabinose, methylglucoronic and galaturonic acids. Its average molecular weight is of about 30,000, and it is a component of the cell wall. Lignin is a mononuclear aromatic polymer also found in the cell wall. Due to the near position of hemicellulose and lignin in the cell wall, adjacent to each other, both these compounds can form a complex termed as lignocellulose (Goyal, Seal & Saxena, 2006). The data in Table 2.2 below shows the oil palm generation and chemical components including OPF:

Table 2.2: Oil palm generation and chemical components

Types of biomass residues	Quantity generated yearly, $tha^{-1}y^{-1}$	Chemical components, %				
		Cellulose	Hemi-cellulose	Lignin	Extractives	Ash
Empty fruit bunch	4.420	38.3	35.3	22.1	2.7	1.6
Palm kernel shells	1.100	20.8	22.7	50.7	4.8	1.0
Palm kernel trunks	2.515	34.5	31.8	25.7	3.7	4.3
Fronds	10.880	30.4	40.4	21.7	1.7	5.8
Mesocarp fibers	2.710	33.9	26.1	27.7	6.9	3.5
total	21.625					

Source: Saka (2005), Singh, Huan, Leng and Kow (1999) and Yang, Yan, Chen, Lee, Liang and Zheng (2004)

2.6 RUBBER TIRES

Other effect of technology and development in economy worldwide is the increasing demand of automobiles and vehicles. With increasing of the automobiles demand, people will confront with a severe problem which is the dilemma between environmental pollution from waste tires and the shortage of rubber resources (Jun et al., 2008). It is believe that from 2008, there will be more than 3 billion tires discarded every year around the world. This also may occur because of the short life span of the tires. Therefore, it is necessary for the academia and researchers to develop methods and ways to minimizes and recycling the waste tires because the proportion of these waste tires being recycled are remains negligible (Yang, Kim, Lee, Kim, Jeon & Kang, 2004). Jun et al. (2008) stated that waste tire rubber is an ideal raw material for the functional composite panel because it possesses some unique properties: excellent energy

absorption, characteristically large elastic deformation, better sound insulation, and durability and abrasion resistance, anti-caustic and anti-rot.

Several researches have been done to study the potential and the characteristics of composite that produced from waste tire rubber. Yang et al. (2004) recovered that rice straw-waste tire particle composite boards had better flexural properties than wood particleboard, insulation board, fiberboard, plywood and various other construction materials. They also stated that this composite are suitable as sound absorbing insulation boards and as flexural material for construction such as flexural insulating materials for curved walls. Research by Jun et al. (2008) is conducted to determine the feasibility of manufacturing of wood-rubber composites. This research also yield the improvement in properties of the composites produced.

2.7 CONCLUSION

Based on all researches and journals available, there are many fibres have been used to replace the role of wood raw materials in composite production. This also solves the environmental pollution that cause by those materials. Numbers of study have utilized the oil palm biomass which is its empty fruit bunches (EFB), trunk (OPT) and stem but none of it have mentioned about the trimmed oil palm fronds (OPF). There is abundance of trimmed OPF been produced yearly and it has high potential to be used in wood-based industries.

Other than that, none of the researched mixed the waste rubber tires with other than rice straw fibres. That is why this research also purpose mix the OPF fibre with waste rubber tires in particle board because of its properties that stated by Jun et al. (2008). In conclusion, this research will produce particle boards from trimmed OPF

fibre and waste tire rubber that will help to decrease the number waste OPF and waste rubber tires which produce yearly in Malaysia and might be in the whole world.